Reorganizing TRIZ Solution Generation Methods into Simple Five in USIT

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Trials to make TRIZ Simple

1980s in Israel SIT (Systematic Inventive Thinking)

1995 Ed Sickafus (Ford Motor Co.) adopted SIT and developed into USIT ("Unified Structured Inventive Thinking").

1999 Nakagawa learned USIT and revised it further in Japan.

The present paper is a further trial of making TRIZ simpler and more unified.

1. Introduction

TRIZ is a powerful methodology for creative problem solving.
- 40 Principles of Invention
- 76 Standards of Inventive Solutions
- Trends of Evolution of Technical Systems
- Separation Principle, etc.

However, the penetration of TRIZ into industries has been slow.

Mostly because the huge body of methods and knowledge bases is not easy to understand and even confusing to TRIZ learners.

Three Main Phases of Problem Solving (as USIT understands)

(I) Problem Definition phase
(II) Problem Analysis phase
(III) Solution Generation phase

(I) & (II) prepare for making breakthroughs during (III).

We now focus on phase (III).

The present paper shows:
"The whole body of TRIZ solution generation methods are reorganized into simple five methods in USIT which can be used in a simple, unified, and effective way."

2. Mapping TRIZ Methods onto USIT Framework

2.1 Basics of USIT as a New Framework

The whole procedure of USIT
is well defined in a flowchart
and can be followed with guidelines easy to learn.

USIT does NOT use knowledge bases
(except the ones in your brain)
nor software tools.

USIT uses the concept of Objects-Attributes-Functions.

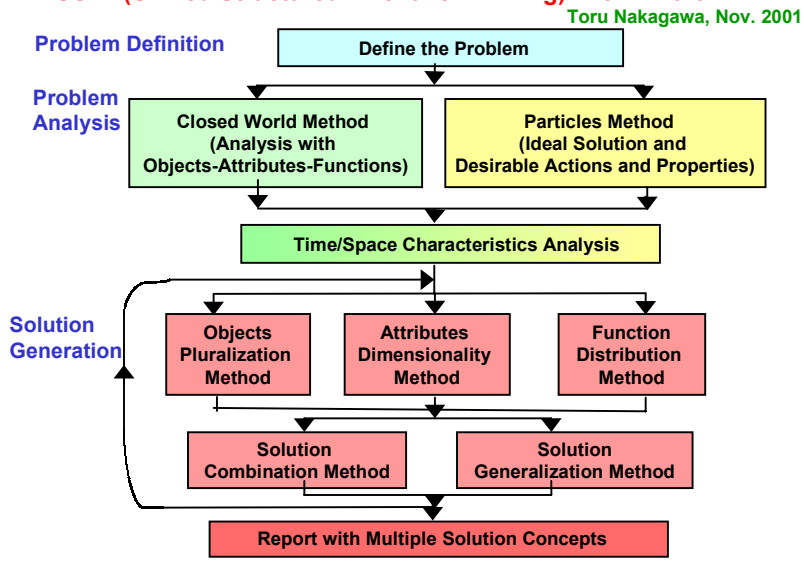
Solution Generation Methods in USIT

1. Object Pluralization Method
   Pluralize the Object in the system: 0, 2, 3, ... ∞ , 1/2, 1/3, ... 1/ ∞
2. Attribute Dimensionality Method
   Change the dimensionality of Attributes of Objects in the system:
   Activate/deactivate an attribute. Vary Attributes in Space and Time.
3. Function Distribution Method
   Distribute (or re-arrange) the Functions among the Objects in the system
   (including newly introduced Objects): Move, unify, separate, etc.
4. Solution Combination Method
   Combine two (elements of) solutions into a heterogeneous solution.
   Combine in time, in space, in parts, etc.
5. Solution Generalization Method
   Generalize the solution by use of plain, generic terms.

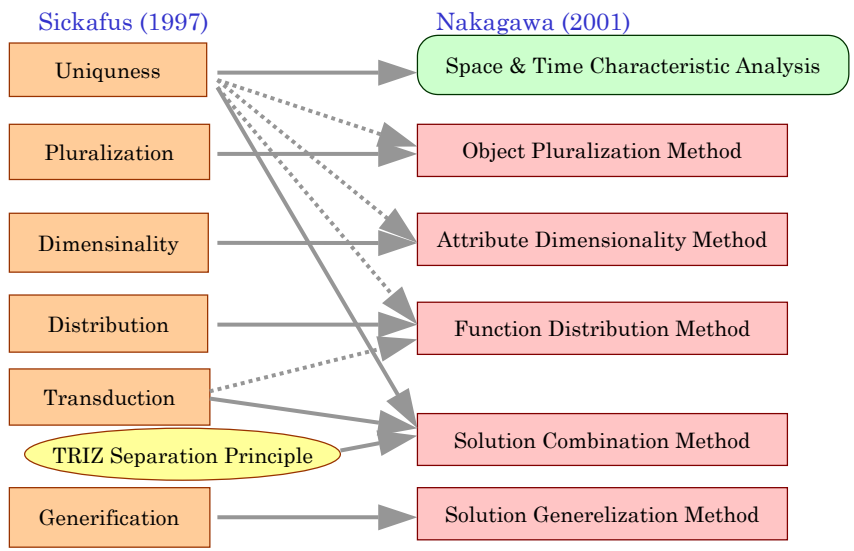
Use these techniques repeatedly to obtain multiple solutions.

USIT (Unified Structured Inventive Thinking) Flow Chart

Toru Nakagawa, Nov. 2001



Evolution of the USIT Solution Methods

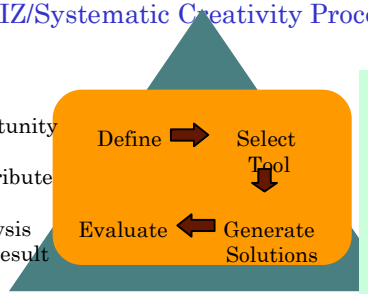


2.2 TRIZ Methods for the Solution Generation Phase

Darrell Mann: "Hands-On Systematic Innovation" (2002)

TRIZ/Systematic Creativity Process

- Psychology
- 9-Windows
- Problem/opportunity explorer
- Function/attribute analysis
- S-curve analysis
- Ideal Final Result



- Solution evaluation

- Select tool

- Technical contradictions/ Inventive principles
- Physical contradictions
- S-Field analysis/ Inventive standards
- Trends of technological evolution
- Resources
- Knowledge/Effects
- ARIZ
- Trimming
- Ideal Final Result
- Psychological Inertia Tools
- Subversion analysis

2.3 Sources of TRIZ Solution Generation Methods

Three big collections of TRIZ methods are reclassified in the present study:

Inventive Principles: 40 principles * sub-principles
Ref. Salamatov (1999) [P15a] etc, [P20abc], etc.

Inventive Standards: 76 standards
Ref. Salamatov (1999) [S1-2.1.2] etc.

Trends of Evolution of Technological Systems: 31 trends
Ref. Mann (2002) [T12], etc.

Additional source:
Heuristics in TRIZ/USIT: 21 heuristics * sub-categories
Ref. Sickafus (1997) [H5a] etc.
A trial by Sickafus to merge TRIZ and USIT and to express it in a manner similar to the Inventive Principles.

TRIZ Methods (by Mann) reclassified according to USIT

[Problem Analysis tools]	[Solution Generation tools]
Technical contradictions (Contradiction Matrix)	40 Inventive Principles
Function Analysis (S-Field analysis)	76 Inventive Standards
Trends of Technological Evolution	Trends of Technological Evolution
Formulation of Physical Contradictions (by ARIZ)	Separation Principle
Ideal Final Result (Smart Little People)	Self-X Principle
	Trimming

[Knowledge for supporting the process] Resources
Knowledges/Effects

[Overall procedure] ARIZ (corresponds to the whole USIT)

2.5 Mapping, Regrouping, and Describing Processes

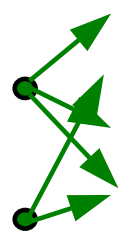
(Step 1) Map all the TRIZ sub-methods onto the five USIT methods

We examined the implication and made 1-to-n mapping.

TRIZ Inventive Principle
3. Local Quality

[P3c] If two functions are to be performed by the same object but this causes problems, divide the object into two parts.

[P3d] Redesign your object and environment so that each part of the object must be in conditions proper for operation.



USIT Five methods

1. Object Pluralization Method
2. Attribute Dimensionality Method
3. Function Distribution Method
4. Solution Combination Method
5. Solution Generalization Method

(Step 2) Regroup them hierarchically
in the USIT framework.

Submethods in USIT are added/enhanced much.

(Step 3) Describe guidelines of USIT submethods.

Done repeatedly in parallel to Step 2.
USIT submethods cover the intention of TRIZ submethods
but are not restricted with them.
Keep the levels of abstraction to be most useful/illustrative
as guidelines to breakthrough solutions.

(Step 4) Illustrate the solution schemes.

3. USIT Solution Generation Methods

3.1 Table of the USIT Solution Generation Methods

USIT Five methods

1. Object Pluralization Method (7 submethods)
2. Attribute Dimensionality Method (8 submethods)
3. Function Distribution Method (9 submethods)
4. Solution Combination Method (6 submethods)
5. Solution Generalization Method (2 submethods)

Documents published in "TRIZ Home Page in Japan":

One-page table:	As a reminder
Simple version:	Guidelines of submethods
Full version:	Detailed guidelines. Appendix of the paper.
Extended version:	Detailed reference to TRIZ submethods.

(1) Object Pluralization Method

(1a) Eliminate the Object (into 0).
(Simplification, Trimming)

(1b) Multiply the Object (into 2, 3, ..., ∞).

(1c) Divide the Object (into 1/2, 1/3, ..., 1/∞). ➡ See detail:

(1d) Unify multiple Objects into one.

(1e)* Introduce a new/modified Object.

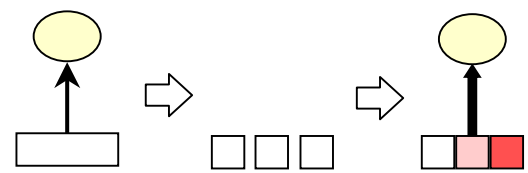
(1f) Introduce an Object from the Environment.

(1g)* Replace a solid Object
with a powder/fluid/liquid/gaseous Object.

(1c) Divide the Object (into 1/2, 1/3, ..., 1/∞).

Divide the Object into multiple parts (1/2, 1/3, ..., 1/∞),
modify the parts (slightly,
or differently for different parts),
and combine them for using together in the system.

P1 Segmentation
P2 Taking away
P3 Local quality
P15 Dynamicity



USIT Solution Generation Methods (1c) *

(1c) Divide the Object (into 1/2, 1/3, ..., 1/∞).

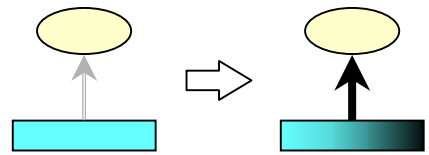
- Guidelines for the division: P1 Segmentation, P15 Dynamicity
  - into mutually independent parts, to perform their own functions better
  - easy to assemble/disassemble
  - easy to replace/repair specific parts
  - movable against one another
  - to make the object or the system flexible
- Divide the object into multiple separated parts to eliminate undesirable interference — P2 Taking away, P3 Local quality
- Divide into much smaller parts and use them together .
  - easy to handle/transfer
  - to increase the surface area per weight and increase interaction
  - more flexible

P1 Segmentation
S2-2 Evolution of SFM
S5-1 Introduction of substanses under restricted conditions

USIT Solution Generation Methods (2d)

(2d) Introduce/enhance a spatial Attribute or distribute/vary in space a harmful/useful Attribute or Attribute's value.

Introduce or enhance an Attribute related to the space, or activate an Attribute (or vary the Attribute's value) depending on different places in space (or different parts of an Object).



(2) Attribute Dimensionality Method

(2a) Deactivate/make irrelevant the harmful Attribute.

(2b)* Activate/involve a new useful Attribute.

(2c) Enhance the useful Attribute or suppress the harmful Attribute.

(2d) Introduce/enhance a spatial Attribute or distribute/vary in space a harmful/useful Attribute or Attribute's value. ➡ See detail:

(2e) Introduce/enhance a temporal Attribute or distribute/vary in time a harmful/useful Attribute or Attribute's value.

(2f)* Change the phase, utilize the phase change, or change the inner-structure of the Object.

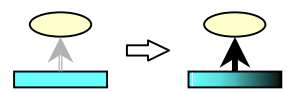
(2g)* Utilize Attributes/properties at the micro level.

(2h)* Improve the properties/performance of the system as a whole.

USIT Solution Generation Methods (2d) *

(2d) Introduce/enhance a spatial Attribute or distribute/vary in space a harmful/useful Attribute or Attribute's value.

- Introduce spatial order/structure:
  H8 Order of objects, H9 Shape-change, H10 Change periodicity of a pattern, H13 Superpose/separate/differentiate objects
- Introduce a space-related Attribute:
  P7 Nesting, P14 Spheroidality, P17 Another dimension
- Introduce spatial structure or inner-structure of Object(s) and vary the Attribute (values) depending on different places
  P3 Local quality, P40 Composites
  S5-1 Introduction of substances under resticted conditions
  T8 Increasing asymmetry, T9 Boundary breakdown
  H10 Change periodicity of a pattern, H11 Symmetry, H12 Localize/delocalize the problem
- Introduce Attribute(s) related to the spatial motion of Object(s)
  P13 Other way round, P15 Dynamicity
  S2-2 Evolution of SFM, S2-4 Complex-forced SFMS
  T10 Geometircal evolution (linear),
  T11 Geometric evolution (volumetric),
  T12 Dynamization



(3) Function Distribution Method

(3a) Reassign the Function to a different Object.

(3b) Divide the compound/multiple Functions and assign them to different Objects or different parts of an Object.

(3c) Unify multiple Functions and assign the unified Function to an Object.

(3d)* Introduce a new Function and assign it to an Object.

(3e) Distribute/vary the Function in space or utilize the spatial distribution/motion/vibration Function.

(3f) Distribute/vary the Function in time.

(3g) Realize the detection/measurement Function.

(3h)* Introduce/enhance the adapting/coordination/control Function.

See detail:

(3i)* Achieve the Function with a different physical principle.

(4) Solution Combination Method

(4a) Combine solutions functionally.

(4b) Combine solutions spatially.

(4c) Combine solutions temporally.

(4d) Combine solutions structurally.

See detail:

(4e) Combine solutions at the principle level.

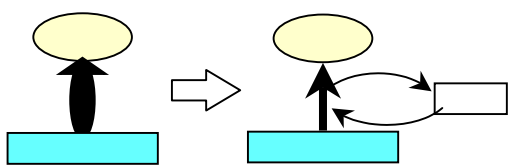
(4f)* Combine solutions at the super-system level.

(3h) Introduce/enhance the adapting/coordination/control Function.

Introduce/enhance Function(s)

for adapting/coordinating/controlling the system

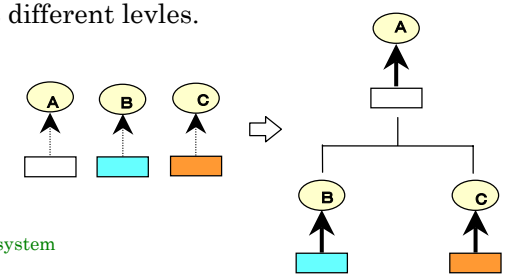
and make the system higher and more intelligent.



(4d) Combine solutions structurally.

Combine multiple solutions
by forming a (hierarchical) functional structure
in such a way that the solutions are
performed alternatively under different conditions or
performed at different levles.

P3 Local quality
P15 Dynamicity
T25 Design point
T30 Design methodology
S3-1 Transitions to bisystem and polysystem



(5) Solution Generalization Method

(5a) Generalize/specify the solution
for associative thinking. ⇨ See detail:

(5b) Construct a hierarchical system of solutions.

3.2 Merging TRIZ Minor Methods into USIT

TRIZ Separation Principle:
(Step 1) Find conditions in which the opposite requirements in the Physical Contradiction are separable.
(Step 2) Find partial solutions to fulfill the requirements separately.
(Step 3) Combine the partial solutions in a compatible manner.

⇨ USIT (4) Solution Combination Method
corresponds to (Step3) exactly.

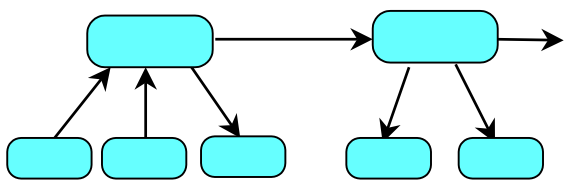
Trimming:
⇨ USIT submethod (1a) 'Eliminate the Object'

Ideal Final Result [the 'Self-service' principle]:
⇨ included in USIT submethod (3h)
'Introduce/enhance the adapting/coordination/control Function'

(5a) Generalize/specify the solution for associative thinking.

Replace the technical/specific terms in a solution
with plain/generic terms,
form a plain solution template,
and then obtain new specific conceptual solutions
in an associative way.

H18 Genericize object's functions
H19 Genericize solutions



3.4 Using the Table of USIT Solution Generation Methods

(1) Study TRIZ in its full aspect: ⇦ Extended version

Different TRIZ methods in the solution generation phase can be studied in a simple and unified structure.

(2) Learn USIT from the beginning: ⇦ Simple version

Learn guidelines of submethods with illustrations and examples.

(3) Study USIT fully: ⇦ Full version

Full extent of USIT methods with detailed guidelines

(4) Apply USIT methods in practice: ⇦ One-page table

Post the table on the wall for reminding.

USIT Solution Generation Methods

(1) Object Pluralization Method

a. Eliminate
b. Multiply into 2, 3, ..., ∞
c. Divide into 1/2, 1/3, ..., 1/∞
d. Unify
e. Introduce or modify
f. Introduce from the Environment.
g. From solid to powder/liquid/gas

(2) Attribute Dimensionality Method

a. Deactivate a harmful
b. Activate a useful
c. Enhance a useful or suppress a harmful
d. Introduce a spatial attribute or vary in space
e. Introduce a temporal attribute or vary in time
f. Change the phase or the inner-structure
g. Attributes at the micro level
h. Properties of the system as a whole

(3) Function Distribution Method

a. Reassign to a different Object
b. Divide the compound Functions and assign them separately
c. Unify multiple Functions
d. Introduce a new Function
e. Vary the Function in space, use space-related Functions.
f. Vary the Function in time.
g. Detection/measurement Function.
h. Enhance adapting/coordination/control
i. With a different physical principle

(4) Solution Combination Method

a. Combine functionally
b. Combine spatially
c. Combine temporally
d. Combine structurally
e. Combine at the principle level.
f. Combine at the super-system level

(5) Solution Generalization Method

a. Generalize/specify
b. Hierarchical system of solutions

4. Discussion

Prerequisites for applying USIT Solution Generation Methods:

Understanding the system in terms of Objects, Attributes and Functions, and its uniqueness in space and in time.

i.e. Understanding of the mechanism of the system.

They must be prepared during the (I) and (II) phases.

USIT prepares these understandings in a systematic way:

(I) Problem Definition phase in USIT:
Problem statement: define the problem to solve.
Sketch and Root causes: examine the mechanism of the problem.

(II) Problem Analysis phase in USIT:
Closed-World Method: analyze with Objects, Attributes, and Functions
Space & Time Characteristic Analysis: uniqueness in space and in time
Particles Method: ideal solution and image of approaches to it.

Use USIT process and TRIZ tools complementarily.

Use USIT as the principal process for problem solving for guiding human thinking in the group work in industries.

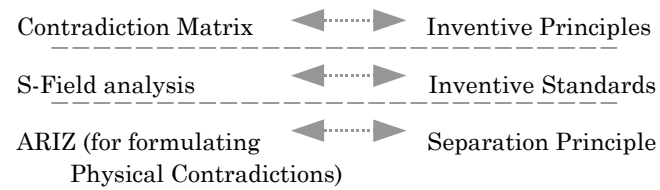
Use TRIZ tools as the knowledge bases of scientific/technological knowledge, examples of applying the methods, and various resources, properties, and functions.

Situations where the KB tools are effective during USIT:
USIT (1e) Introduce a new/modified Object.
(2b) Activate/involve a new useful Attribute.
(3d) Introduce a new Function and assign it to an Object.

Poor ways: Let a software tool guide the thinking process.
Work in a group mainly around a software tool.

TRIZ in the traditional way:

Solution Generation Methods in TRIZ have their own analysis methods:



Separate analysis methods provide insufficient and narrow understanding of the problem.

➡ Solution generation in TRIZ is not easy to understand and difficult to learn for beginners.

The separation of "analysis-solution pairs" is the root cause of the "TRIZ slow-penetration problem".

5. Conclusion

The whole body of TRIZ solution generation methods
(Inventive Principles, Inventive Standards,
Trends of Evolution, Separation Principle, etc)
are reorganized into simple five methods in USIT.

USIT has guidelines to apply TRIZ-origin methods
in a simple, unified, and effective manner.

USIT provides a practical basis
for learning and applying the essence of TRIZ
in real problem solving in industrial situations.